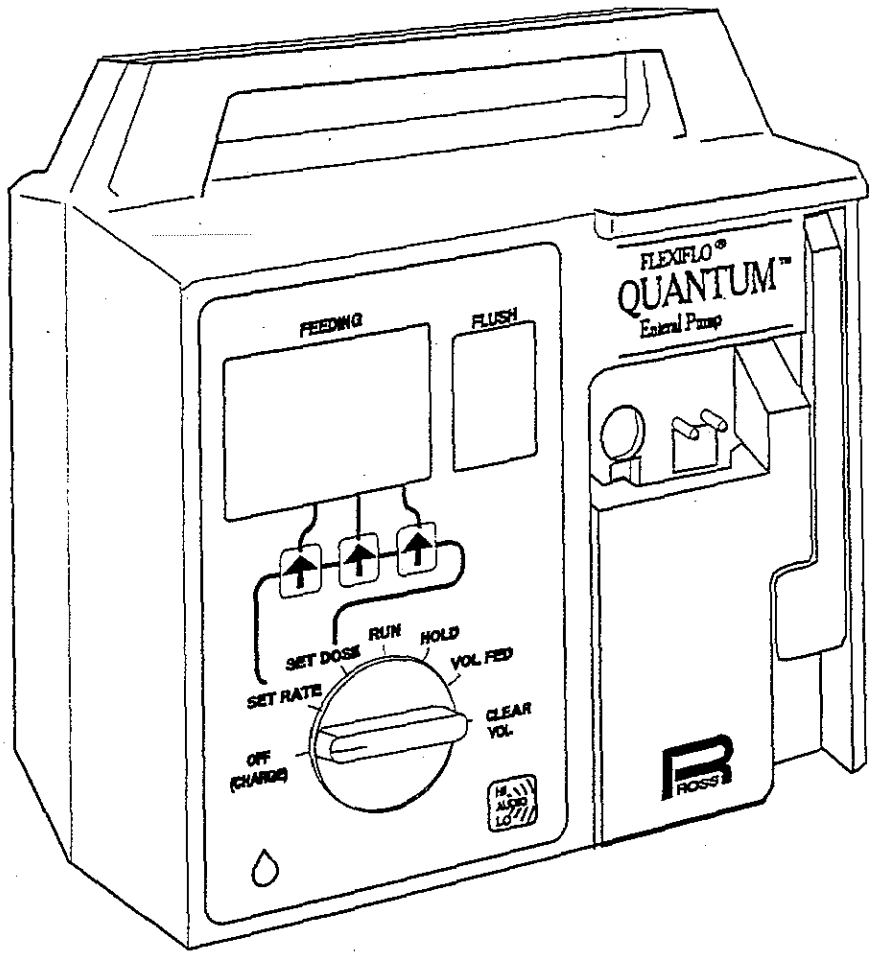
FLEXIFLO® QUANTUM™
Enteral Pump

MAINTENANCE AND REPAIR MANUAL

For Enteral Use Only
Not for Parenteral Use



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Section 1

INTRODUCTION

The FLEXIFLO® QUANTUM™ Enteral Pump is microprocessor-controlled to provide enteral feeding. The pump is volumetric, and uses a variety of specially designed feeding sets. The pump delivers a volume of enteral product, which is set by the user. The pump also has an optional FLUSH mode. When FLUSH mode is selected, a 25 mL flush will purge the feeding set and an indwelling feeding tube each hour and with certain alarm conditions. The pump also has an automatic priming feature. *(See Figure 1-1, Flexiflo Quantum Enteral Pump.)*

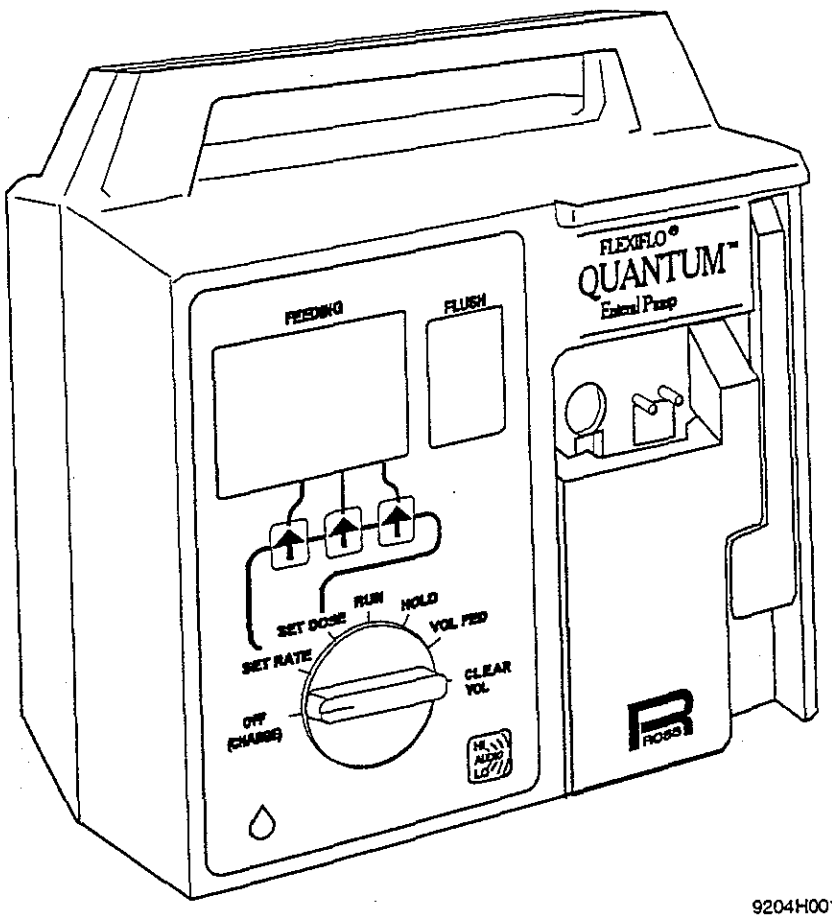

Figure 1-1. Flexiflo Quantum Enteral Pump

1.1
PEDIATRIC USE

Because the Flexiflo® Quantum™ Pump (when FLUSH sets are used in the Optional FLUSH MODE) will deliver at least 600 mL of additional fluid (flush solution) per day on continuous feeding, **the FLUSH sets must NOT be used for feeding infants under 12 months of age. In addition, use of the FLUSH feature in all pediatric patients 12 months of age or older must be carefully evaluated:** A physician, who has training in pediatrics, must take into account the effect of this additional volume on intestinal tolerance and overall fluid balance of the individual patient and should, accordingly, determine the maximum amount of flush solution to be hung.

CAUTION

The Quantum Pump can be used on pediatric patients provided the patients can tolerate a feeding range within the pump operational specifications. Those specifications are:

- The flow rate range of the Quantum Pump is 1-300 mL/hr in 1 mL increments.
- The flow rate accuracy of the pump is ± 10% (see page 13 of the Quantum operating manual for checking pump accuracy).
- The mean occlusion pressure limit of the Quantum Pump is 15 PSI.

If these specifications are not appropriate for a given patient, the Quantum Pump should not be used. All enteral pumps have the potential to bolus-feed or overdeliver, which is an important consideration in feeding volume-sensitive patients. In these patients, a volume of product no more than four times the hourly feeding rate should be hung.

1.2
PRECAUTIONS

WARNING

POSSIBLE EXPLOSION HAZARD EXISTS IF USED IN THE PRESENCE OF FLAMMABLE ANESTHETICS.

- Low-level electrical emissions are commonly observed when fluids are administered using an enteral feeding pump. The emissions observed with the Quantum Pump may create artifacts on voltage sensing equipment such as ECG, EMG, and EEG monitoring devices if the monitoring device is not operating correctly or has loose or defective connections to its sensing electrodes. These artifacts may be mistaken as actual physiologic signals, and may vary at a rate that is associated with the delivery rate set on the pump. To determine if the abnormality in the monitoring device is caused by the Quantum Pump, set the pump so it is temporarily not delivering fluid. Disappearance of the artifact indicates it was probably caused by the pump. Proper setup and maintenance of the **monitoring device** should eliminate the artifact.

- Caution should be exercised when using this pump in the automatic FLUSH mode for patients with volume sensitivity or volume restriction (i.e., cardiac, renal, or pulmonary patients). For such patients, the feed only mode (using the system without automatic flush feature) may be desired.

- This pump is designed to deliver only liquid enteral feeding product (standard liquid product, infant formula, or reconstituted powder that has been thoroughly mixed into solution) and water.

Not For Parenteral Use

Confirm proper placement and function of patient's enteral feeding tube (nasogastric, jejunostomy, gastrostomy, etc.). Failure to do so may result in vomiting and/or aspiration. Verify the following before initiating feeding.

1. A Quantum Pump Set is being used.
2. Cassette is properly seated in pump and door is closed.
3. Flow rate is set at the prescribed mL/hr.
4. Before putting pump in RUN mode, be sure line clamps are fully open.
5. If a pump set with flush bag is used, be sure that both line clamps are closed during setup and when the door on the pump is open. Otherwise, the fluids will mix.

1.3
SCOPE

The material contained in this manual is limited to technical information necessary for performing preventive maintenance; periodic testing functions; various service tests; interpreting system alarms; and troubleshooting to the level of sub-assembly replacement. Replacement of parts is limited to those parts listed in *Section 6, Replaceable Parts and Repair*. Specific instructions for operating this product are contained in the Flexiflo Quantum Enteral Pump Operating Manual.

1.4
ABOUT THIS MANUAL

The purpose of this Technical Service/Maintenance and Repair Manual is to provide instructions necessary for testing the Flexiflo Quantum Enteral Pump, troubleshooting alarms, and replacing field replaceable assemblies and components. Refer to the pump Operating Manual for detailed information on operating instructions.

This manual is organized into seven sections as follows:

Section 1 Introduction
Section 2 Specifications
Section 3 Theory of Operation
Section 4 Maintenance and Service Tests
Section 5 Troubleshooting
Section 6 Replaceable Parts and Repair
Section 7 Drawings

1.5
USER QUALIFICATIONS

The Flexiflo Quantum Enteral Pump is for use at the direction of or under the supervision of licensed physicians, and by licensed or certified health care professionals who are trained in the use of the pump and the administration of enteral fluids.

WARNING

SERVICE INSTRUCTIONS ARE FOR USE ONLY BY QUALIFIED BIOMEDICAL ENGINEERS (BME), BIOMEDICAL ELECTRONICS TECHNICIANS (BMET), OR ROSS FIELD SERVICE PERSONNEL. TO AVOID PERSONAL INJURY OR INSTRUMENT DAMAGE, DO NOT PERFORM ANY REPAIR OR CORRECTIVE ACTION UNLESS FULLY TRAINED AND AUTHORIZED TO DO SO. USER-SERVICEABLE PARTS ARE LIMITED TO THOSE ITEMS LISTED IN SECTION 6.

1.6
WARNINGS, CAUTIONS, AND NOTES

Throughout this manual, three types of alert messages are used: warnings, cautions, and notes, as explained below. Pay attention to all alert messages.

WARNING

A WARNING CONTAINS A SPECIAL SAFETY EMPHASIS AND MUST BE OBSERVED AT ALL TIMES. FAILURE TO OBSERVE A WARNING IS POTENTIALLY DANGEROUS.

CAUTION: A CAUTION usually appears in front of a procedure or statement. It contains information that could prevent irreversible damage or hardware failure. Neglecting a CAUTION could result in serious injury.

Note: A Note highlights information that helps explain a concept or a procedure.

1.7
INSTRUMENT INSTALLATION PROCEDURE

The Instrument Installation Procedure consists of three steps: unpacking, inspection, and pump operational self-test. Procedures for performing these steps are provided below.

Note: Product damage may occur unless proper care is exercised during the unpacking and installation process. The battery pack may not be fully charged upon receipt. Do not place the pump in service if it fails the operational self-test.

Instrument installation should be performed only by qualified technicians or Biomedical Engineers (*see Section 1.5, User Qualifications*).

1.7.1
UNPACKING

Use care when unpacking the pump. Retain the packing slip and save all original packing material for returning pump to the Ross Products Division Service Center, in the event the pump is damaged or fails the operational self-test. For information on returning a pump, *see Section 5.1, Technical Assistance.*

1.7.2
INSPECTION

Inspect the packing container thoroughly for possible damage. Do not use the pump if it appears to be damaged in any way. Should there appear to be damage to the pump, contact the Ross Products Division Service Center for further instructions.

1.7.3
PUMP OPERATIONAL SELF-TEST

Note: Following repair, do not place the pump in service until the operational self-test has been conducted. Perform the operational self-test as follows (*see Figure 1-2, Operational Self-test*):

1. Confirm the CAIR® and slide clamps are closed on feeding and flush containers.

2. Suspend an Osmolite® or Ensure® filled feeding container at a height of 20 inches to the side of or behind the pump. Partially fill the flush bag and suspend it on the side of or behind the pump, at the same height as the feeding bag.

3. Seat the cassette into cassette holder on the pump door, with the orange plunger facing the pump. When the cassette is securely seated, close the pump door.

4. Confirm the CAIR and slide clamps are open.

5. Place the interlocking connector, with cover removed, into a container. Turn pump rotary control knob to SET RATE. The operational self-test should occur, followed by an automatic priming of the set.

6. Select a flow rate of 300 mL/hr and a dose of 10 mL (*see Figure 1-3, Set Rate, Priming Complete*). Turn the control knob to RUN. Fluid should flow into the container.

7. When the 10 mL dose is completed, the pump flushes 25 mL of water, followed by an audible alert and visual dose complete alarm. This will complete the operational self-test.

Note: If a malfunction failure is detected by the operational self-test, an alarm will occur. Do not place the pump in service. Contact the Ross Products Division Service Center for further instructions.

Note: Connect the pump to AC power for at least 16 hours to charge the battery pack.

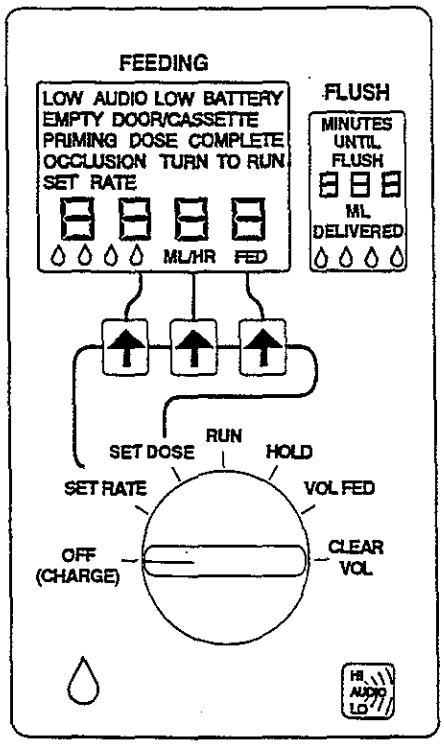

Figure 1-2. Operational Self-Test

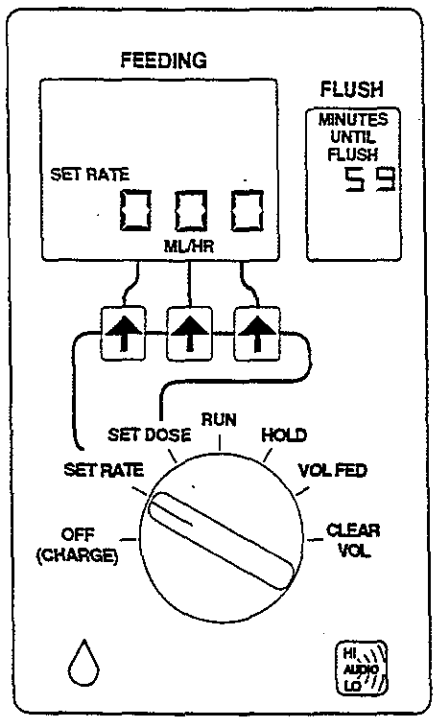

Figure 1-3. Set Rate, Priming Complete

Section 2

SPECIFICATIONS

POWER:	
Voltage:	100 to 130 VAC, 47 - 63 Hz, Single Phase
Power:	4 watts (average)
Fuse:	0.5 ampere, slow-blow type
AC line cord:	AC power cord, hospital grade, nondetachable (10 feet)
Leakage:	Less than 100 microamperes
MECHANICAL:	
Height:	8.25 inches
Width:	7.5 inches
Depth:	6.0 inches (8.0 inches with pole clamp)
Weight:	7.2 pounds
OPERATIONAL SPECIFICATIONS FLOW RATES:	
Range:	1 - 300 mL/hr
Increments:	1 mL/hr
Accuracy:	± 10 percent *(refer to Section 4.2.10, Delivery Accuracy Test)*
Pressure:	Pumps against 15 psi (mean) back pressure before occlusion alarm
BATTERY OPERATION:	
Type:	2.1 Ah rechargeable sealed lead acid
Voltage:	8 volts; the pump will fully recharge in a maximum of 8 hours if turned off, or a maximum of 12 hours if running
Expected Life:	When fully charged, 8 hours at 125 mL/hr
STANDARDS:	Designed and manufactured to meet requirements of UL 544 (1976)

Section 3

THEORY OF OPERATION

This section describes the theory of operation of the Flexiflo Quantum Enteral Pump. The theory of operation details the following:

- ❑ General description
- ❑ Mechanical overview
- ❑ Electronics overview

3.1 GENERAL DESCRIPTION

The Flexiflo Quantum Enteral Pump includes the following features:

- ❑ Automatic priming (manual priming is optional)
- ❑ Automatic flush feature
- ❑ Dose setting
- ❑ Safeguards to protect against overdelivery:
  - Motor speed is continuously monitored
  - Software senses malfunctions that could result in gravity flow
- ❑ Volume-fed accumulation displays for enteral product and flush solution
- ❑ Flow-rate selection from 1 to 300 mL/hr in 1 - mL increments
- ❑ Accuracy to ±10% *(see Section 4.2.10, Delivery Accuracy Test)*
- ❑ Eight-hour battery operation at 125 mL/hr when fully charged
- ❑ System self-test
- ❑ Simple setup (one-hand cassette loading)
- ❑ Memory: Automatic retention of the following until pump is turned off and disconnected from AC power:
  - FEED and FLUSH volume accumulations (VOL FED)
  - SET RATE
  - SET DOSE
- ❑ Alarms include the following:
  - OCCLUSION
  - EMPTY
  - DOSE COMPLETE
  - TURN TO RUN (pump left idle for more than 5 minutes)
  - LOW BATTERY

- DOOR/CASSETTE
- SET RATE

❑ Two level adjustable alarm volume

3.2
MECHANICAL OVERVIEW

The principal mechanical elements of the Flexiflo Quantum Enteral Pump include: the cassette; the pumping mechanism (three motors); pressure sensor, the ultrasonic fluid sensors; an orange plunger knob; and interconnect/interface electronics.

When a cassette is locked into the operating position, the pump performs a self-test to verify the integrity of the internal systems. The operation of the plunger motor moves the plunger, causing a pumping action.

A valve motor selects the feed or flush valve, depending on the command input. An additional valve motor then opens or closes an inlet valve or outlet valve to control fluid flow into the pumping chamber.

3.2.1
CASSETTE

The pump cassette operates on a fluid displacement principle, in conjunction with the mechanism, to deliver fluid volumetrically (*see Figures 3-1 through 3-4*).

The cassette contains two chambers separated by the inlet valve. The upper (air trap) chamber receives fluid from a container through either the feed or flush valve.

The pumping cycle begins when the outlet valve is opened and the diaphragm is displaced by the plunger, expelling the fluid. At the end of the pumping stroke (approximately 0.08 inch or 2.0 mm), the outlet valve is closed, the inlet valve opens, and the plunger retracts, allowing fluid to refill the pumping chamber. At this time, the inlet and outlet valves are reversed and the cycle repeats itself.

A bubble detector located between the feed/flush valves and the air trap will detect air entering the air trap. A proximal air-in-line alarm will sound when a predetermined amount of air is detected. This detector is also used to determine empty container conditions.

A pressure sensor located distal to the pumping chamber monitors pressure on the distal side of the cassette.

A flow regulator (orange plunger knob) is incorporated in the distal side of the cassette. This orange plunger knob can be used to manually control the flow when the cassette is not inserted in the pump.

When the cassette is inserted in the door and the door is closed, a mechanism opens the orange plunger knob to allow flow to be controlled by the pump. Upon opening the door, the same mechanism closes the regulator, ensuring no flow to the patient.

The lower chamber of the cassette is called the pumping chamber. The pumping chamber receives fluid from the air trap chamber through the inlet valve, and expels fluid through the outlet valve when the diaphragm covering the pumping chamber is displaced by the plunger.

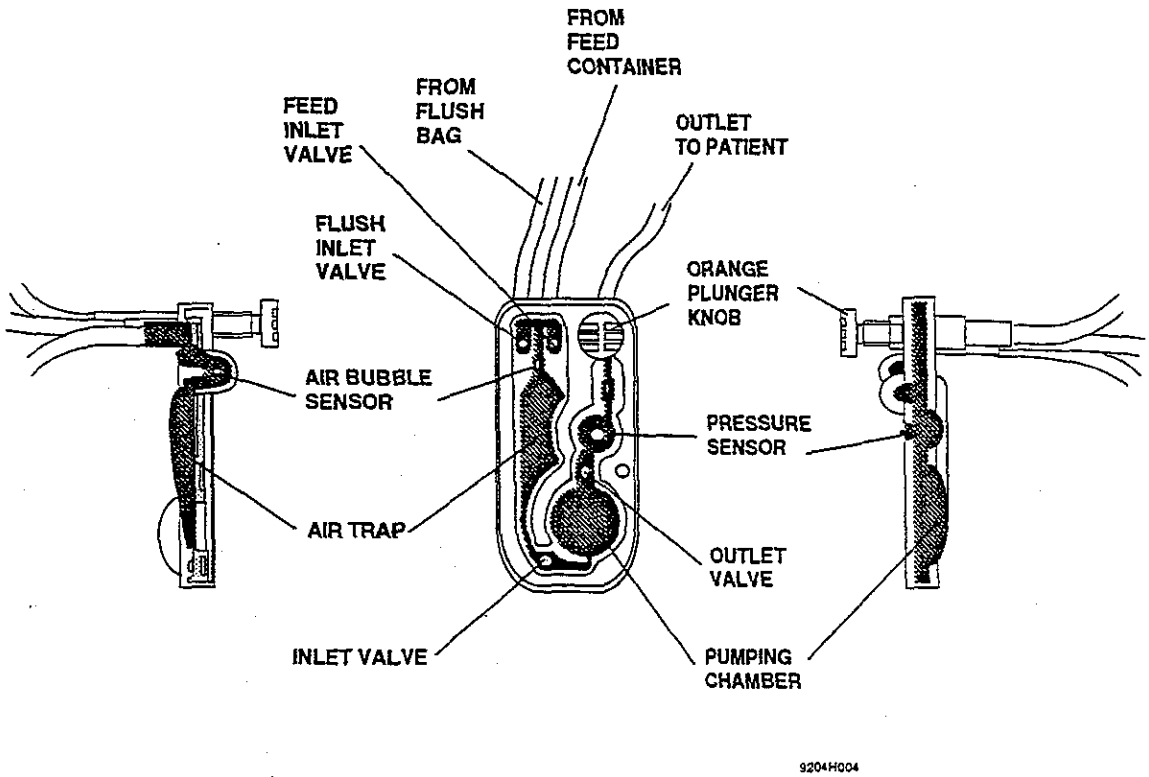

Figure 3-1. Cassette, Feed and Flush

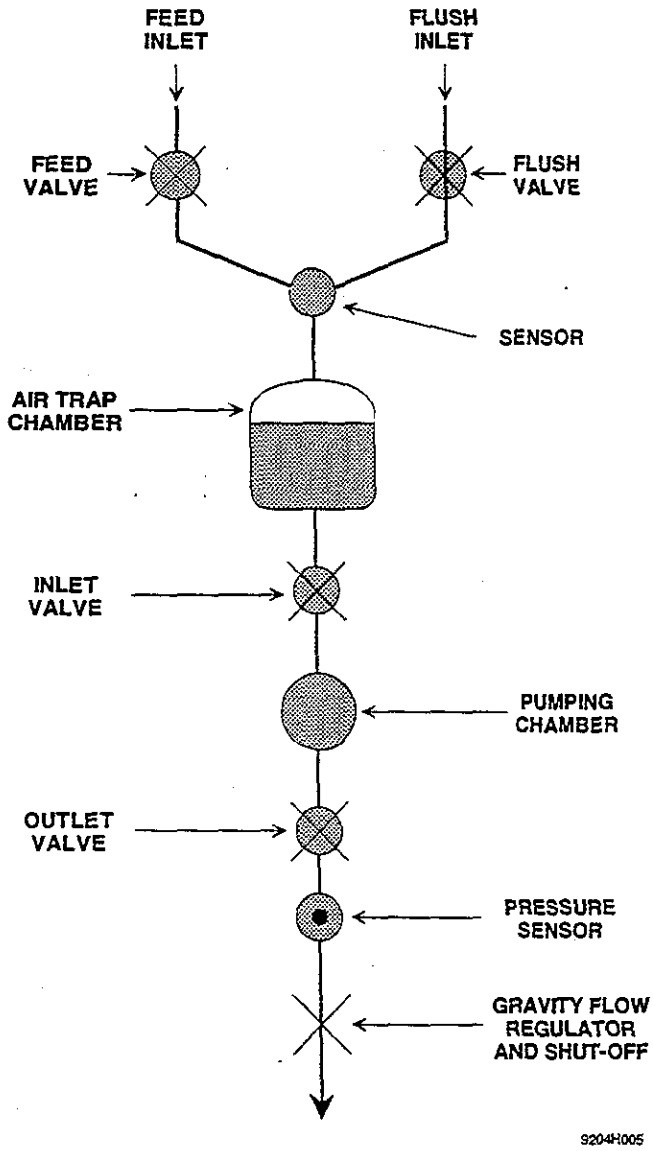

Figure 3-2. Fluid Path in the Cassette

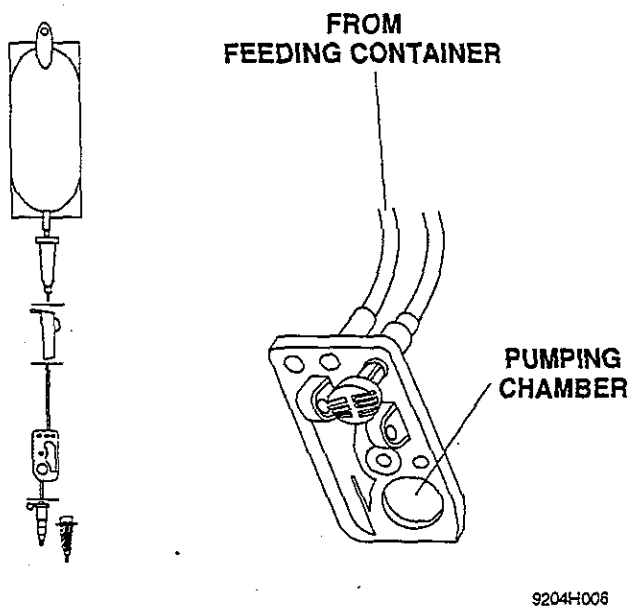

Figure 3-3. Single Inlet Cassette

NOTE:
ONE BAG SET VERSION SHOWN. OTHER BAG AND SET VERSIONS ARE AVAILABLE.

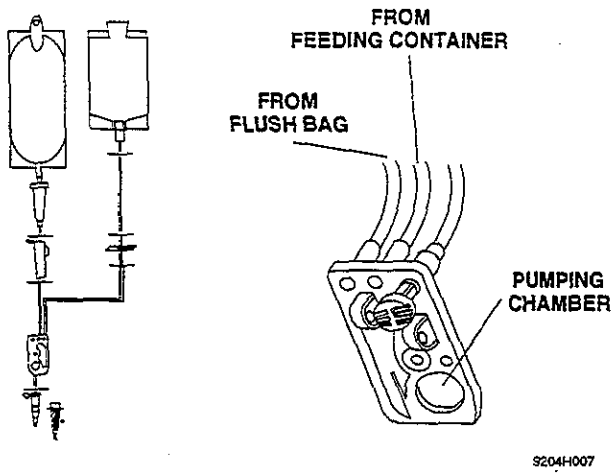

Figure 3-4. Dual Inlet Cassette

3.2.2

MECHANISM ASSEMBLY

The mechanism assembly is a fully self-contained unit. This assembly contains a stepper motor that controls the delivery chamber inlet and outlet valves of the cassette. It also contains a stepper motor that controls the feed and the flush valves of the cassette.

The mechanism assembly consists of the following major assemblies and subsystems: (*see Figure 3-5, Mechanism Valve Pins and Sensor Locations, Cassette Door Breakaway*)

- Feed/flush valve subsystem
- Inlet/outlet valve subsystem
- Plunger drive subsystem
- Cassette door
- Air bubble (ultrasonic) sensor
- Pressure sensor

During operation, the plunger motor drives a screw that is coupled to a nut in the plunger. The motor action and screw move the plunger forward, causing the delivery of approximately 0.33 mL of fluid per cycle. The plunger motion synchronizes with the action of the valve motor, providing controlled fluid delivery.

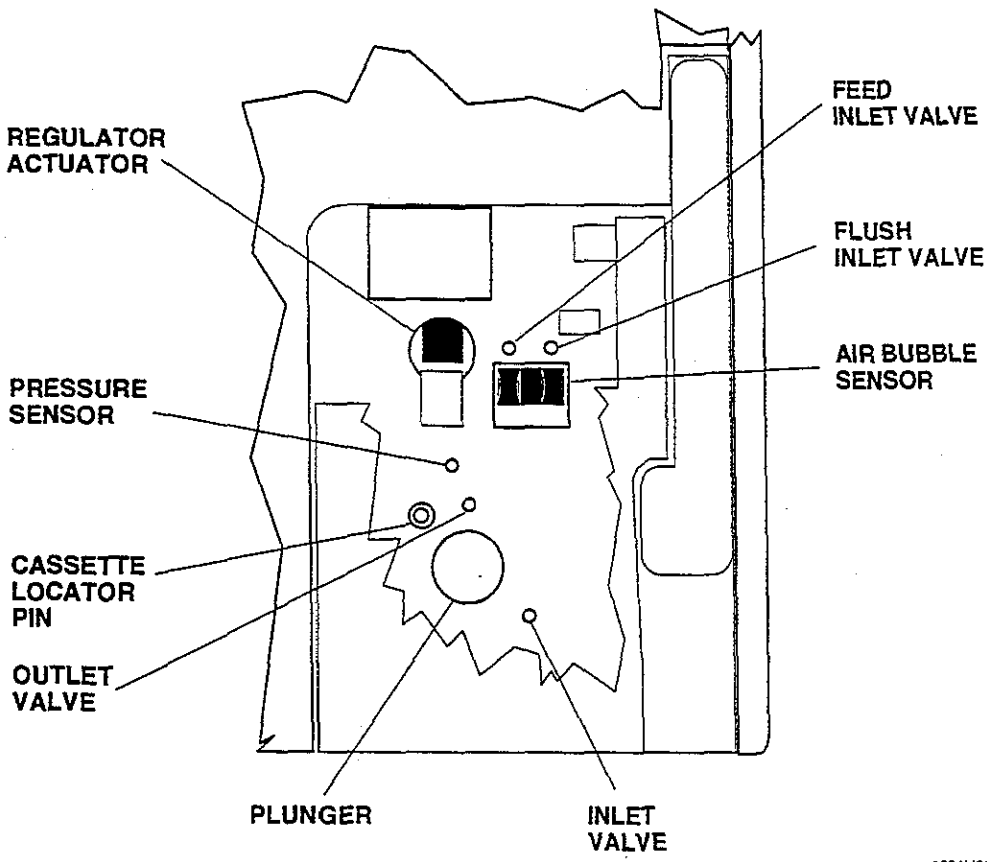

Figure 3-5. Mechanism Valve Pins and Sensor Locations (Cassette Door Breakaway)

3.2.3
MOTORS AND VALVES

Three stepper motor systems control the pumping action of the mechanism. One motor and associated valve system control the pumping chamber inlet and outlet valves, while the second motor and associated valve system control the feed and the flush inlet valves. The third stepper motor controls plunger movement.

3.2.4
FEED/FLUSH VALVE ASSEMBLY

Note: The inlet and outlet valve system is similar to the feed/flush valve system. Both perform similar functions and contain similar parts. Due to the similarities, only the feed/flush valve system is described.

The feed/flush valve system includes a motor designed to rotate a cam. When the cam is positioned at the top dead center (home position), both valves are closed. Clockwise rotation (when viewed from the motor side) from the home position opens the feed valve. The flush valve remains closed. Counterclockwise rotation opens the flush valve.

The feed/flush valve system consists of the stepper motor with attached cam, flag, two rockers, and associated valve pins. The flag passes through an interrupter module as it rotates with the cam. If the flag is in the interrupter module at the incorrect time sequence, a motor phase loss is detected and a malfunction alarm is triggered.

The rocker is the connecting link between the cam and the valve pin.

When the pump is turned on, home position is determined by the motor rotation, as the flag passes through the interrupter.

3.2.5
PLUNGER DRIVE ASSEMBLY

The plunger drive assembly includes a stepper motor designed to rotate about one and two-thirds revolutions per pump cycle. Every pumping cycle results in a displacement of 0.33 mL of fluid. The motor then reverses, the plunger returns to home position, and the cycle repeats for the duration of fluid administration. This system includes the following components:

- Stepper motor
- Ball thrust bearing
- Screw/coupler assembly
- Plunger/support system

The ball thrust bearing rests against the mechanism chassis. As the cassette displaces fluid, the resulting load (due to pumping action and backpressure) is absorbed axially by the ball thrust bearing.

The screw/coupler assembly links the motor and the plunger. This assembly includes a flag that passes through an interrupter.

When the pump is turned on, home position is determined from the flag and interrupter, and factory calibration data (internally stored in the mechanism memory). During operation, the flag and interrupter are also used to check for loss of motor steps (phase loss).

3.3
ELECTRONICS OVERVIEW

The following section contains information on the electronic circuits in the Flexiflo Quantum Enteral Pump. Each functional circuit is described individually. Many of the functions are implemented on more than one printed wiring assembly (PWA). Where this is true, the locations of the circuit components are described. The Electronics Block Diagram and Schematics are shown in *Section 7, Drawings.*

3.3.1
MICRO-CONTROLLER UNIT (MCU)

(U1 on the MCU PWA)

The Micro-Controller Unit (MCU) is an NEC µPD78C18. This chip has 32K ROM and 1K RAM internal memory, 3 timers, 37 I/O ports, an 8 channel A/D converter, and a serial port. The internal system clock is provided by the following components: a 7.68 MHz Crystal (Y1), C21, and C22 capacitors. During a reset condition, all ports default to high impedance input ports. The software configures the ports as inputs or outputs during the system initialization. All MCU inputs connected to the Display PWA are protected from static discharge.

3.3.2
KEY SWITCHES

(S1 - S4 on the Display PWA; RN1 and RN2 on the MCU PWA)

Switches S1 through S4 are normally open key switches. When momentarily closed, the key switches activate the three arrow and AUDIO HI/LO switch functions on the front panel. The switches are connected to the MCU input ports A0, A1, A2, and A3, through RN2. RN1 provides the active pull-up so that when the switch is open (not selected), the line is high. When the switch is closed (is selected), the line is low. RN2 provides static discharge protection of the MCU.

3.3.3
ROTARY SWITCH

(U4 - U10, RN1, RN10, RN11, Q4, and S5 on the Display PWA; RN1, RN2, R1, R2, and CR2 on the MCU PWA)

U4 - U6, U8 - U10, are Hall Effect switches. The rotary knob assembly on the front case contains a magnet that, as the rotary knob assembly is turned, causes magnetic flux to pass through one of the Hall Effect switches, to turn the switch's output transistor on. RN1 provides the active pull-up for the Hall Effect open collector outputs. These outputs

are coded by U7, to generate the three signals, ROT0, ROT1, ROT2 as listed in *Table 3-1, Rotary/Hall Effect Switch Signals.*

Table 3-1. Rotary/Hall Effect Switch Signals

Rotary Switch State	ROT2	ROT1	ROT0
OFF	1	1	1
SET RATE	1	1	0
SET DOSE	1	0	1
RUN	0	1	0
HOLD	1	0	0
VOL FED	0	0	1
CLEAR VOL	0	1	1

To reduce power consumption, power to the Hall Effect switches is controlled by R10, R11, and Q4, and by the software using HSENSEN.

On the MCU PWA, the signals ROT0, ROT1, and ROT2, are connected to the MCU input ports A5, A6, and A7, through RN2. RN1 provides the active pull-up, and RN2 provides the static discharge protection for the MCU.

When the rotary knob assembly is in the OFF (CHARGE) position, the magnet will energize the reed switch S5, and the normally closed contact will open, disconnecting SPSTIN from +BUSS. When the rotary knob assembly is turned from the OFF (CHARGE) position, the reed switch is de-energized and the normally closed contact will close, connecting SPSTIN to +BUSS. This line is nominally 11V when the AC power cord is plugged in, and is the battery voltage when the AC power cord is not plugged in (7V - 8.6V). SPSTIN, on the MCU PWA, is converted into a digital signal (-4.5V) with R1, R2 and CR2, and is connected to the MCU input port A4. SPSTIN is also used on the Power Supply PWA. R1 provides the static discharge protection for the MCU. R2 limits the current drain on the battery under certain error conditions.

3.3.4
MOTOR POSITION SENSORS

(U2, U3, U4, Q2, R21, and R24 on the Sensor PWA; RN3 on the MCU PWA)

Within the pumping mechanism, each of the three motors is attached to a flag that, as the motor turns, interrupts one of the optical interrupter modules mounted on the Sensor PWA. When the flag is not present, the light from the LED strikes the phototransistor, and turns it on. When the flag is present, the light from the LED is blocked and the phototransistor is off. Current, through the LED portion of the optical modules, is controlled by R24. To reduce power consumption, the power to the optical interrupter modules is controlled by R21 and Q2, and by the software using PSENSEN.

On the MCU PWA, RN3 provides active pull-up of the optical interrupter output transistors. These three signals are connected to the MCU input ports F1, F2, and F3.

3.3.5
AIR BUBBLE (ULTRASONIC) SENSOR

(Sensor PWA)

The sensor, X1, is a pair of identical piezoelectric crystals mounted so one of the crystals is a transmitter and the other is a receiver. The cassette has a channel that fits between the two crystals. During normal pump operation, fluid passes through this channel. The transmitter crystal is energized with an electrical signal and will generate an ultrasonic signal. If there is fluid in the channel, the receiver crystal will "sense" this ultrasonic signal and generate an electrical signal. If there is no fluid, the receiver crystal will not "sense" the ultrasonic signal and will not generate an electrical signal.

The transmitter consists of a sweep oscillator, VCO, and a driver stage. The sweep oscillator (U1B, U2-2, U2-3, C5, and R15 - R18) cycles at approximately 120 microseconds, with a 50 percent duty cycle. The portion of U2 in the circuit is used for a solid rail to rail CMOS signal for the timing. The output of the sweep oscillator is on C2, and the charge/discharge amplitude is between 2 to 3 volts. The VCO is composed of U2, C7, and R21. U2 is a phase lock loop and the VCO portion sweeps from 4 to 6 MHz. R21 and C7 regulate the center frequency. The crystal driver consists of push-pull, emitter-follower complementary transistor pair, Q4 and Q5.

The receiver consists of an amplifier, detector, and buffer. The amplifier consists of Q2 and Q3, and associated discrete components, biased by 2V5REF (2.5V) and designed for solid power supply rejection. The amplifier has a considerably larger positive swing for the detector. The detector is an emitter follower, Q1, for maximum input impedance. C1 and R4 produce a time constant of 450 microseconds. Since the time between peaks is approximately 60 microseconds, the output remains high through the transmission time. The buffer, U1A, R1, and R2 amplify the detected signal by a factor of two.

3.3.6
PRESSURE SENSOR

(U6, U7, U8, related resistors and capacitors on Sensor PWA)

The pressure sensor circuit is divided into three sections: the reference, the pressure amplifier, and the AC amplifier.

The reference circuit consists of: U1, U6, Q1, CR2, R17 - R20, R22, R23, C9, C11, and C12. The power signal VMOT is filtered by R22, C11, and C12. The 2.5V reference device is biased by R18. U6B buffers the 2.5V and U6A is boosted by Q1 to generate the main reference voltage of 3.75V. The 3V75REF signal is limited by CR2 to VDIG (5 volts), for protection of the MCU.

The pressure amplifier (U7, R6, R11 - R16, C2, and C3) is a differential amplifier with an approximate gain of 300. C2 and C3 are part of an auto zero system inside U7. The combination of R13/R11 permits R12 to compensate up to 3 mV of offset input from the strain gauge. In the event of larger offsets, R13 may be clipped out of the board. A two pole 30Hz Bessil active filter consists of R1, R3, C4, C5, and U8A, which acts to filter the 500 Hz auto zero switching frequency.

The AC amplifier (R4, R7, R9, R10, CR1, CR3, C7 and C8) amplifies small rapid changes on the pressure amplifier signal. These changes, when negative in direction, may indicate an occlusion alarm, if they occur at a time immediately after the opening of the outlet

valve. At high back-pressure, the pressure signal is larger, thus the negative spikes are larger. CR1 and CR3 clip these spikes to a manageable level for the AC amplifier and for the MCU.

3.3.7
POWER SUPPLY AND BATTERY

(Power Supply PWA; U6, R13, R14, and CR4 on the MCU PWA)

This section describes the power supply and charger schematic.

3.3.7.1
GENERAL

The power supply consists of the switcher, the voltage regulator, and the battery charger. The schematic diagram contents are described in the following sections. Note the following operation modes:

- AC OFF. Pump is not plugged into AC line voltage and is not operating.
- AC OFF, Pump ON. Pump is not plugged into AC line voltage and is operating on battery power.
- AC ON. Pump is plugged into AC line voltage and is not operating.
- AC ON, Pump ON. Pump is plugged into AC line voltage and is operating.

3.3.7.2
SWITCHER

The primary function of the switcher is to convert AC line power to an isolated 11V DC power. Conversion is accomplished through flyback topology.

Protection against high line voltage spikes and high input power demand (potential fire hazards), is provided by F1, F2, and VR1. Attenuation of conducted emissions is provided by C1, C2, and T1. The switcher DC voltage requirement is provided by U1, R1, and C3. The voltage of the current mode controller IC, U2, is provided by components CR1, CR2, CR4, R2, R3, C4, and C9.

IC, U2 oscillates at 80 KHz (dictated by R4 and C5 values), controlling the duty cycle of the switch Q1, via R5 and R6. R9 is the current sensor. R8 and C7 filter the ramp voltage across R9, then feed it back to U2. U2 is configured so the DC voltage, at pin 9 (ERR+) is the peak voltage across R9. U2 also controls the delivered power through T2 to the output circuit (output voltage). Since voltage at U2-9 is limited to 1.25 V, the maximum current through Q1 is limited, thus providing the output short protection. The optocoupler, U3, is part of the main regulation loop, and provides the UL544 isolation barrier.

T2's winding short protection is provided by CR5 and C6, by delivering a high voltage across R9 to the U2 inhibit pin. The value of C6 directs a low hiccup frequency to protect Q1. The clamp winding of T2, along with CR3, provides a quick intermediate energy transfer to C3, limiting the maximum voltage across Q1.

The soft start timing is provided by C12. This timing is long enough for U2-14 (Vcc) voltage to reach its minimum level.

Energy from T2 is rectified by C23, C24, and CR11. A secondary 12 V control loop, used for protection in the event of primary loop failure, is produced by CR10, C19, R23, and U4. A feed forward negative voltage, created by CR12 and C25, along with Q9, R56, R57, and CR14, generates signal HKDC, which is the housekeeping DC voltage required for powering the main regulation loop. Signal HKDC is at ground level when the AC is off, and CR12 blocks unnecessary battery power drain.

Signal HKDC is smoothed by R58, R59, U9, C30, C31, C32, and R60, which also creates and smooths the 2.5 V reference voltage. Both voltages are at ground level when AC is off. The main loop control is produced by R39, R41 through R46, C27, C28, C29, and U8B. False primary loops are eliminated using components Q7, R22, and CR9, by enabling regulation only after the +BUSS reaches 9 V.

3.3.7.3

VOLTAGE REGULATORS

The VMOT regulator (U8A, Q4, and Q5) is at 9.35 V when AC power is on. Component Q3 is kept in an off state. Q3 does not interfere with the regulation by Q2, which is kept in the on state by signal HKDC, using CR8, R11, and R12.

When the pump is operating on battery power, the series pass transistor, Q4, serves as a switch. Q4 can be turned on temporarily by signal SPSTIN and permanently by POWERHOLD. The transistor Q4 then delivers battery voltage to VMOT and powers the necessary circuits including U5, the 5 V regulator. The 5 V regulator supplies power to the digital circuits.

3.3.7.4

BATTERY CHARGER

The battery charger provides the constant current source. The charger is made up of Q6, Q8, U6B, and R33, along with associated passive devices. The current carrying device is Q6, with R33 being the sense regulator. When AC power is off, Q8 is off and Q6 is on. There are two current source levels and a trickle current, R20. The charge current control is achieved by controlling the voltage at U6-6. *Table 3-2, Battery Charger Current Control,* lists the charge current state as a function of the control signals.

Table 3-2. Battery Charger Current Control			
LOCHRG	CHRG OFF	J26-3 TO J26-4	CURRENT
L	L	Open	High/Battery 1
L	L	Short	High/Battery 2
H	L	Open	Low/Battery 1
H	L	Short	Low/Battery 2
X	H	X	Trickle
(X = don't care)			

The current level and voltage at U6-6 are controlled by components U7A, Q10, R31, R32, R62, and R63. Signal BAT2 is high (not logic level) when a short is introduced at the battery connector J26, pins 3 and 4 (which implies that battery number two is connected to J26). The charge current, in this case, is lower since Q10 will be on. The Q6 overpower protection is provided by U7A. When voltage across Q6 generates more than 2.5 V at U7-4, the charge current switches to Low.

LOCHG_REQ (low charge request) signals the MCU of the battery voltage level. LOCHG_REQ is generated by U6A, U7B, U7C, and U7D. A differential amplifier, produced by U6A, R24 through R28, and C20, reads the battery voltage as it is being charged. The differential amplifier output is compared by U7C, which generates the LOCHG_REQ when the battery reaches a previously assigned voltage level. The voltage level depends upon whether U7-1 or U7-13 is low or, alternatively, whether battery number one or battery number two is connected.

Signals HKDC and LOCHG_REQ are multiplexed by U6 into port F0, on the MCU PWA. The selection is made by the output signal HSENSEN. When HSENSEN is low, LOCHG_REQ is present at PF0. When HSENSEN is high, HKDC is present at PF0. This multiplexing is required to expand available input port lines.

3.3.8
ANALOG-TO-DIGITAL CONVERTER INPUTS

(C1-C7, CR1, CR3, R3-R7, R11, and R12 on the MCU PWA)

The analog to digital (A/D) converter is an integral part of the MCU chip. Supply voltage filtering to the converter is provided by R12 and C1. Over-voltage protection to the converter input is provided by CR1 and CR3. To bring it into the 3.75 V range, VMOT voltage division is provided by R2 and R4.

3.3.9

STEPPER MOTORS AND MOTOR CONTROL

(Q1 through Q12, RN4, RN5, and RN6, on the MCU PWA)

The MCU directly controls the driving function to the three stepper motors in the pumping mechanism. Each of the motors is a four phase stepper motor. The plunger motor has a winding impedance of 8.5 Ohms, whereas the other two motors have 12 Ohm windings. Four output ports are used for each motor, with one port for each motor winding. When the MCU is in the reset state, the output ports are configured as high impedance input ports. The resistor networks RN4 - RN6 provide active pull-down to confirm the transistors are off. The series resistors protect the MCU ports from a large surge of current when the transistor is turned off. When there is a major current surge, the output ports will momentarily sink the current. A large amount of charge is stored in the gate, and this charge is dissipated to ground. The 10 K Ohm resistor keeps the charge dissipation (i.e., current flow) at a safe level, so it will not damage the MCU. The transistors are 3055 logic level FETS, that turn on fully with less than 4.5 V at the gate, allowing them to be driven directly from the MCU output ports.

3.3.10

LED RUNNING INDICATOR

(Q1, LED1, R1, R2, and R3, on the Display PWA)

The LEDRUN signal is generated by the MCU and is at 50 percent duty cycle with a one second interval. When LEDRUN is high, Q1 is turned on and R1 controls the current through LED1. Biasing for Q1 is provided by R2 and R3.

3.3.11

WATCHDOG AND POWER-UP RESET

(U2 and R15 on the MCU PWA)

Watchdog and reset functions are performed by the supervisory circuit, U2, (MAX694). When the main power signal, VDIG rises from 0 V to 5 V, U2 holds the reset signal *RST low, until 200 milliseconds after VDIG rises above 4.65 V, then *RST goes high, ensuring correct reset operation of the micro-controller. When VDIG falls below 4.65 V, U2 will set *RST low to protect against incorrect MCU operation during brown-out and power down conditions. U2 also generates a 200 millisecond *RST low pulse, if the signal *WDCLK ever fails to toggle within a 1.6 second period. Other features of this chip, which include battery monitoring and power fail detection, are not used in this application.

3.3.12

AUDIO INDICATOR

(U5, C10, and the buzzer, on the MCU PWA)

The buzzer is a self oscillating, voltage controlled device. The higher the voltage, the higher intensity the output. The buzzer is controlled by the MCU by sinking current through the buzzer and through R8 and R9, via U5 (open drain output). Two audio levels are achieved by allowing different currents to flow through the buzzer and resistors, thus changing the

voltage across the buzzer. For the higher audio level, AUDIOHI is high, which enables U5B and U5C. The signal AUDIOEN turns on all gates in U5, and there will be 5 V across the buzzer, since R8 is 0 Ohm. For a low audio level, AUDIOHI signal is low, which disables U5B and U5C. The signal AUDIOEN turns on U5A and U5D, resulting in approximately 4 V seen across the buzzer (due to a 1 V drop across R9).

3.3.13
BACKLIGHT POWER AND CONTROL

(EL1, U11, Q4, Q5, and related resistors and capacitors on the Display PWA)

An electroluminescent (EL) panel backlights the LCD panel for two minutes after the pump enters RUN mode. An inverter unit, U11, is used to convert low level DC voltage into a 120 VAC, 400 Hz signal, causing the EL panel to illuminate. The MCU controls whether the EL panel is on, with the signal ELON. When the signal ELON is active high (5 V), the Q3 emitter is biased at 4.3 V, and with R12 and R13 acting as a voltage divider, the voltage seen at U11-1 is 5.2 V nominal. The transistor, Q5, acts as a regulator, when input voltage fluctuates, due to motors turning on and off. Components, C4, C5, and R12 act to filter the VMOT line. When signal ELON is low, Q3 is off, Q5 is off, and the voltage at U11-1 is 0 V.

3.3.14
LIQUID CRYSTAL DISPLAY

(U1, U2, U3, and R4, on the Display PWA)

The LCD is driven by a pair of LCD driver chips, the Motorola 145000 master chip, U1, and the 145001 slave chip, U2. These chips accept the display data through a serial input stream on the signal TXD. New data is sent to the drivers from the MCU every 250 milliseconds and is stored in the internal register. The driver chips generate all the waveforms to drive the LCD. The selection of R4 at 39 K Ohms controls the update rate at which the LCD is refreshed. The internal register is bit mapped to the segments on the LCD. Twenty front plane lines and 4 back plane lines indicate there are 80 segments on the LCD, although only 72 segments are used. The master and slave chips are daisy chained with the serial output from the master going to the serial input of the slave. The serial output of the slave is connected to the MCU with signal LCDDO, for use during the power-on self-test.

3.3.15
SERIAL DEVICE SELECT

(U3 and U4 on the MCU PWA)

The serial port is used to access two devices: the EEPROM and the LCD driver chips. These two devices expect input data to be valid on opposite clock edges. The SLDC-EE (select LCD or EEPROM) and SWR-RD (select WRite or ReaD) signals are required to create the correct chip select and clock waveforms. When signal SLCD=EE is high, the LCD driver is selected. When signal SLCD=EE is low, U4A inverts it to select the EEPROM with signal EECS.

When signal SWR-RD is high, a write operation is enabled and signal *SCLK is inverted by U4B to signal GSCLK. When signal SWR-RD is low, a read operation is enabled, and

signal *SCLK is buffered (not inverted) by U4B to GSCLK. Signal GSCLK is buffered by U3C when the LCD is selected to generate signal LCDCLK. When the EEPROM is selected, signal GSCLK is inverted by U4D to generate signal EECLK.

The signals EECD and SLCD-EE also control which device data is read into the serial input port. The multiplexing circuit consists of U3A, U3D, and U4C, for selecting between both device inputs. Signals E2DO and LCDDO are pulled up to VDIG with RN3, because they are coming from other PWAs.

3.3.16
EEPROM

(U5 on the Sensor PWA)

The serial EEPROM 93C46 is located on the Sensor PWA and contains calibration data specific to the pumping mechanism on which it is mounted. The EEPROM contents are read during the initialization, and when a system malfunction occurs, a malfunction number is written during the turn-off procedure.

Section 4

MAINTENANCE AND SERVICE TESTS

This section contains preventive maintenance information, a performance verification test procedure, and battery maintenance information for the Flexiflo Quantum Enteral Pump.

4.1 PREVENTIVE MAINTENANCE

A preventive maintenance program promotes longevity and trouble-free operation of the pump. Such a program should include periodic inspection of the unit, exterior cleaning and sanitizing, and checking for proper operation of the pump by administering performance tests (*see Performance Verification Test, Section 4.2*).

As a minimum requirement, clean the pump after each use. Establish a regular cleaning schedule during use. In addition, clean the pump and complete the Performance Verification Test (PVT) as part of any scheduled service or after any repair procedure.

4.1.1 INSPECTING THE EXTERIOR

Periodically, the pump should be visually inspected for signs of defects such as worn accessories, broken components, or damaged cables. Inspection is applicable after any repair or during normal cleaning procedures. Replace any damaged or defective external parts.

Inspect the following subassemblies for missing or damaged parts and for cosmetic defects:

- ❑ Labels
- ❑ AC power cord
- ❑ Velcro® retainer strap
- ❑ Four rubber feet
- ❑ Door assembly
  - open and unlatch the door
  - check the valve pins, plunger, bubble detector, and locator pin
  - check the roller, door cover, and cassette guide spring.
- ❑ Door handle
- ❑ Faceplate
- ❑ All keypad switches
- ❑ Rotary control knob

- ❑ Pole clamp knob, screw, and insert
- ❑ Case and battery cover
- ❑ LCD screen
- ❑ All external screws

4.1.2

CLEANING AND SANITIZING THE PUMP

For trouble-free operation, check the pump daily and clean immediately after spills occur.

While cleaning, pump should be turned off and unplugged. Do not submerge, autoclave, heat, steam, ETO or radiation sterilize the pump.

The Pump can be cleaned as follows:

HOUSING

1. Clean outside surface with soft cloth and warm, soapy water.
2. For general cleaning, use dishwashing detergent (nonchlorine-based) or isopropyl alcohol.
3. For general disinfecting, use 70% concentration isopropyl alcohol.
4. For disinfecting after exposure to AIDS or hepatitis, use 10% concentration of 5.25% sodium hypochlorite (household bleach). This solution may discolor the pole clamp. **DO NOT SPRAY THIS SOLUTION INTO PUMP CAVITY.** After exposure to tuberculosis, use 70% concentration isopropyl alcohol. These recommendations are not substitutes for official procedures that may differ among institutions.

PUMP CAVITY

To facilitate cleaning, the cassette receptacle door may be disconnected from the face of the pump. However, this should be removed only by a qualified service technician, in the following manner:

1. Tilt pump back.
2. Lift blue lever so cassette door is in open position.
3. Push out on door-release tab to release cassette door.
4. Allow door to open fully.
5. Lift up on door to remove completely from brown hinge.

Reinstall cassette door by following above procedures in reverse order.

6. Do not spray water or cleaning solution into pump cavity.
7. Clean with a cotton swab, soft brush or soft cloth, and warm soapy water.
8. Dry thoroughly.
9. Be sure no soap film or residue is left in the pump cavity.

4.2
PERFORMANCE VERIFICATION TEST

As a part of a preventive maintenance schedule, it is recommended the Performance Verification Test (PVT) be conducted periodically per hospital procedures for compliance with accreditation requirements.

The PVT consists of the tests provided below. These tests can be used for diagnostic purposes during troubleshooting of a malfunctioning pump. The tests are also used to verify the overall performance of a Flexiflo Quantum Enteral Pump, as part of a preventive maintenance schedule. In addition, the PVT must be used for performance verification before a pump is placed back in service after performing any external or internal repairs.

Note: Conduct the PVT exactly as described in this manual for effective and reliable product evaluation information.

4.2.1
POWER ON TEST

Install a feeding cassette in the cassette door. A feeding set with flush bag should be used. Turn the control knob from the OFF (CHARGE) position to the SET RATE position to turn power on. An automatic power-on test sequence is executed. The pump checks to confirm the cassette is primed. If the cassette is not primed, the automatic priming sequence will begin. Automatic priming is indicated by the PRIMING status message on the display. *See Figure 4-1, Power-On Test Display.*

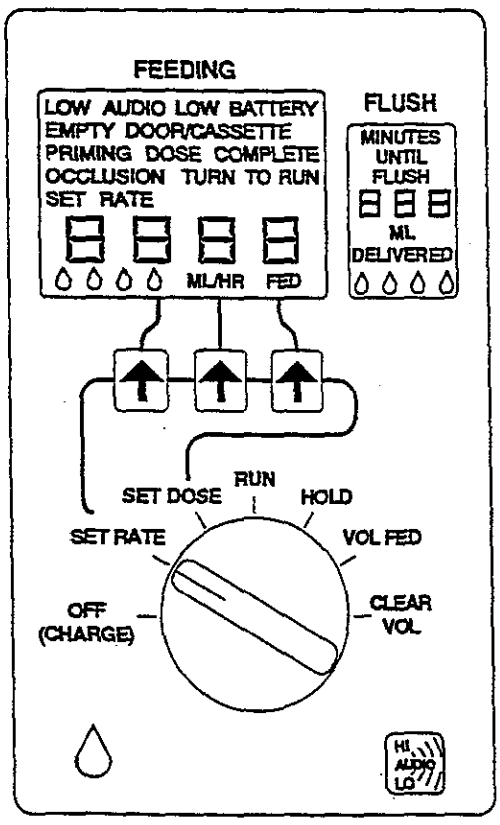

Figure 4-1. Power-On Test Display

Upon confirming the cassette is primed or completing the priming sequence, the pump tests for the presence of a feed-only or flush cassette, the PRIMING message disappears (the FLUSH display screen is blank if using single inlet cassette), and the pump is available for product delivery, at the set rate.

4.2.2
LCD/LED VISUAL CHECK

Turn the control knob to SET RATE. Verify the green LED light is illuminated during the initial power-on test.

Verify the LCD display backlight is illuminated, and the display is clearly readable at eye level, from approximately three feet. Verify all legends appear on the display screen.

4.2.3
KEY SWITCH CHECK

Leave the control knob on the SET RATE position. Press the following keys to verify that each key activates a switch and a display legend appears. Press the three [UP ARROW] keys to confirm the following:

[RIGHT ARROW] key displays the units digits
[MIDDLE ARROW] key displays the tens digits
[LEFT ARROW] key displays the hundreds digits

Press the [AUDIO HI/LO] key and verify the icon LOW AUDIO toggles off and on.

4.2.4
OPEN DOOR CAUTION CHECK

Open the pump door after completing the key switch check, and verify the DOOR/CASSETTE legend appears and audible alarm sounds.

4.2.5
ALARM LOUDNESS CHECK

With the pump alarming, press [AUDIO HI/LO] key to change intensity. Press repeatedly to toggle between the HI/LO audible levels.

Note: In this mode, the legend will not appear, but the audible level will change. Reset by turning to HOLD.

4.2.6
BATTERY LEGEND CHECK

Turn the control knob to HOLD and disconnect the AC plug from the AC outlet. Verify the battery symbol illuminates within 10 seconds. Reconnect AC power after the battery legend check.

4.2.7
DISTAL OCCLUSION TEST

To perform the Distal Occlusion Test, proceed as follows:

1. Insert a primed cassette in the cassette holder, close the door, turn the control knob to SET RATE, and set the rate at 300 mL/hr.
2. Turn the control knob to RUN to start pumping fluid.
3. Once priming is complete and pumping has started, completely occlude the line distal to the cassette. After drops stop falling through sight chamber, verify that an occlusion alarm occurs within 60 seconds.

4.2.8
PROXIMAL OCCLUSION TEST (Only applies to Model C and earlier)

To perform the Proximal Occlusion Test, proceed as follows:

1. Insert a primed cassette in the cassette holder, close the door, turn the control knob to SET RATE, and set the rate at 300 mL/hr.
2. Turn the control knob to RUN to start pumping fluid.
3. Once priming is complete and pumping has started, completely occlude the line proximal to the cassette. After drops stop falling through sight chamber, verify that an occlusion alarm occurs within 60 seconds.

4.2.9
EMPTY CONTAINER TEST

To perform the Empty Container Test, proceed as follows:

1. Insert a dry cassette in the cassette holder, close the door, turn the control knob to SET RATE.
2. After one to two minutes, verify that the pump displays an EMPTY legend on the LCD screen, and an audible alarm occurs. Confirm the FLUSH side of the LCD is blank.

4.2.10
DELIVERY ACCURACY TEST

Fluid head height and viscosity are two variables that can affect flow rate. To check flow rate, use the following procedure:

Select a pump set *without a flush bag* (or fully close clamp on flush bag, if using a feeding pump set with flush bag). Be sure to use a graduated cylinder for volume measurement—not an enteral container. Using Ensure® Complete, Balanced Nutrition™ or Osmolite® Isotonic Liquid Nutrition, fill the feeding container only and set up pump according to instructions. Suspend bag to side or behind and 20 inches above pump (*see Figure 4-2, Typical Pump Setup for Delivery Accuracy Test*).

With a test pump connected to AC power, start the pump and let it run for 15 minutes. Then run product into a graduated cylinder for 30 minutes and compare to rate set on pump:

Rate Set	Amount Expected in Graduated Cylinder at 30 Minutes
76 mL/hr=	34.2 mL to 41.8 mL
150 mL/hr=	67.5 mL to 82.5 mL

If flow rate is incorrect, try a new pump set and repeat procedure.

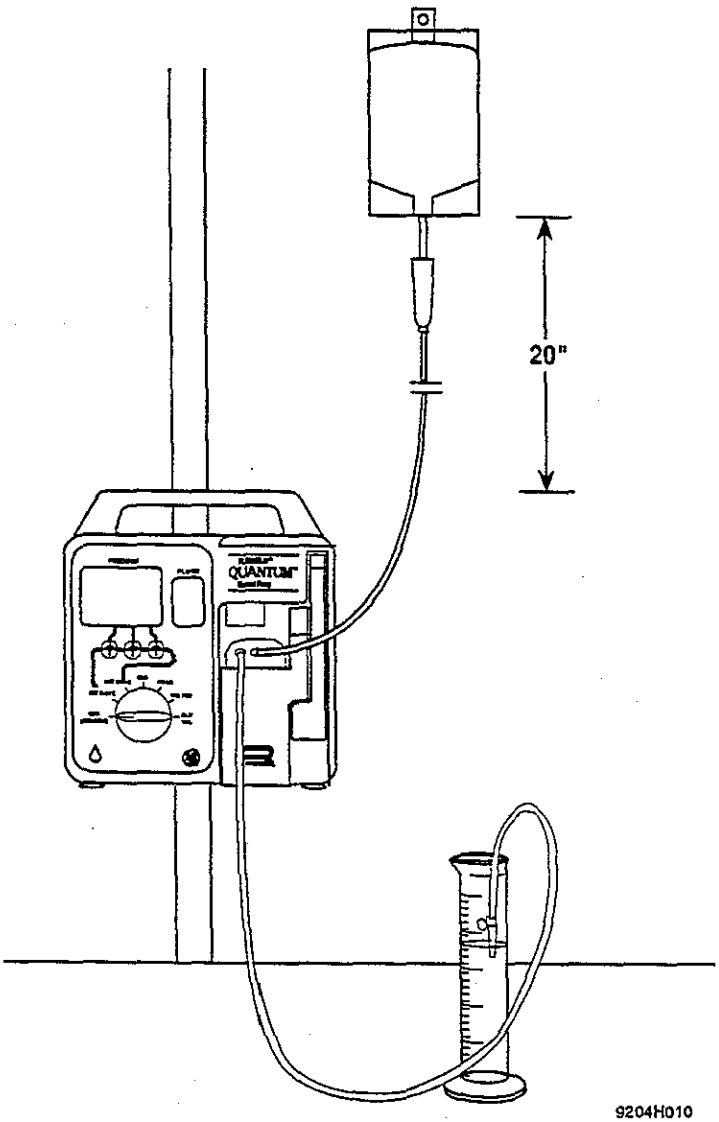

Figure 4-2. Typical Pump Setup for Delivery Accuracy Test

4.2.11 BATTERY CHARGER TEST

To perform the Battery Charger Test, proceed as follows:

1. Disconnect the pump from AC power. Remove the battery cover and the battery. Reconnect the battery with an ammeter in series with pin 1 (red wire), and with a 10-ohm 5-watt resistor across the battery terminals.

2. Connect the pump to AC power, and measure the current on the ammeter within 20 seconds of applying AC power.
3. If the battery has connector pins 3 and 4 connected, the current reading should be 0.8 ± 0.1 amperes. If the battery does not have pins 3 and 4 connected, the current reading should be 1.2 ± 0.15 amperes.
4. Disconnect pump from AC power. Reconnect the battery without the ammeter and resistor. Replace the battery cover and secure.

4.2.12 ELECTRICAL SAFETY TEST

To perform the Electrical Safety Test, proceed as follows:

1. Check the leakage current per the Underwriters Laboratories Standard No. 544, Section 27, pertaining to patient care equipment. Leakage current must not exceed 100 microamperes (AC RMS).
2. Check the grounding impedance per the UL544, Section 33, using the Ground Test Point on the rear of the instrument. The ground impedance must not exceed 0.1 Ohm.

Section 5

TROUBLESHOOTING

This section contains information on obtaining technical assistance from the Ross Products Division Service Center, on audible alarm messages, on malfunction code history, and on troubleshooting the pump.

5.1 TECHNICAL ASSISTANCE

For technical assistance, to order parts, accessories or manuals, contact Ross Products Division. Do not return a pump without first obtaining authorization from Ross Products Division.

5.2 ACCESS TO SOFTWARE VERSION, RUNTIME, AND MALFUNCTION CODE LIST

To access software version, runtime, and malfunction codes, proceed as follows:

1. While pressing the [MIDDLE ARROW] key, turn the control knob to SET RATE. After the LCD initialization, the value displayed will be the software version.
2. Press the [LEFT ARROW] key; the runtime (in tens of hours) will be displayed.
3. Press the [LEFT ARROW] key again and the first (most recent) malfunction code will display. Each successive press of the [LEFT ARROW] key will display the next older code. Each successive press of the [RIGHT ARROW] key will display the next newer code. When there are no more old codes, the display will indicate END. The drops in the flush window will scroll with each new code to indicate multiple codes of the same value in a row.
4. Once the malfunction codes are displayed, the software version and runtime cannot be seen again without turning the pump off and repeating Steps 1 through 3.

5.3 AUDIBLE ALARMS

Alarms signify a condition that requires immediate attention by an operator. Alarms initiate an intermittent audible tone and display a flashing message on the LCD screen. Alarms are caused by the following conditions:

- ❑ Empty feed or flush fluid container

- ❑ Occlusion
- ❑ Low battery
- ❑ Discharged battery
- ❑ Dose delivery completed
- ❑ Turn to RUN
- ❑ Door open or cassette not in place
- ❑ RUN mode with SET RATE at zero
- ❑ System malfunction

Alarm conditions may be set up as follows:

- ❑ Start with the control knob in the OFF (CHARGE) position and no cassette loaded in the cassette door. When the control knob is turned to SET RATE, the pump emits a single beep, then repeated double beep tones within five seconds. This alarm sequence occurs with the control knob in each position except HOLD, where no alarm occurs.
- ❑ Start with the control knob in the OFF (CHARGE) position and a dry cassette loaded, with no fluid in the feeding bag. When the control knob is turned to SET RATE, the pump emits a single beep. As the control knob is rotated through SET RATE, SET DOSE, and RUN, the priming cycle takes place. After approximately 1 minute 20 seconds, a double beep occurs.

5.4 MALFUNCTION ERROR CODES

Malfunction error code numbers, up to two digits, are displayed on the screen to indicate an internal pump malfunction. Refer to *Table 5-1, Malfunction Error Codes and Corrective Action*, to remedy specific problems. If a malfunction occurs that is not listed on the display screen, contact the Ross Service Center or the nearest Ross Products Division representative for further instructions.

Table 5-1. Malfunction Error Codes and Corrective Action

Error Code	Malfunction Description	Corrective Action
1	Stack overflow (software execution failure)	Replace IC, -U1 on the MCU PWA. If problem persists, replace the MCU PWA.
2	Not used	
3	Not used	
4	Stuck key	Check S1 - S4 on the Display PWA. If switch(es) defective, replace the Display PWA.

Table 5-1. Malfunction Error Codes and Corrective Action

Error Code	Malfunction Description	Corrective Action
5	Motor timer error (internal MCU timer failure)	Replace IC, -U1 on the MCU PWA. If problem persists, replace the MCU PWA
6	Rate/Dose parameter, checksum error	Replace IC, -U1 on the MCU PWA. If problem persists, replace the MCU PWA
7	Not used	
8	RAM test failure (MCU internal memory failure)	Replace IC, -U1 on the MCU PWA. If problem persists, replace the MCU PWA
9	ROM checksum test failure	Replace IC, -U1 on the MCU PWA. If problem persists, replace the MCU PWA
10	EEPROM checksum test failure	Problem is on Sensor PWA; replace the pumping mechanism
11	Air sensor test failure	Problem is on Bubble Sensor PWA; replace the pumping mechanism
12	Not used	
13	LCD display driver failure	Possible failure of LCD driver or serial port on MCU PWA. Check and replace as necessary, ICs, U1 or U2 on the Display PWA. If problem persists, replace the Display PWA. If problem recurs, replace the MCU PWA
14	Not used	
15	A/D reference voltage is out of tolerance	Check IC, U1-42 on the MCU PWA; if it reads 3.75 V, replace the MCU PWA. If it reads zero (0), check the pico fuse on Power (F3) Supply PWA. If fuse is functional, problem is on the Sensor PWA. Replace the pumping mechanism
16	A/D ground reference is too high	Replace IC, -U1 on the MCU PWA. If problem persists, replace the MCU PWA

Table 5-1. Malfunction Error Codes and Corrective Action

Error Code	Malfunction Description	Corrective Action
17	Malfunction Code History List is cleared	Check service jumper (JP1) on the MCU PWA. If the Malfunction Code History List is present, no malfunction exists. The service jumper is used to indicate when the malfunction history list has been cleared. This code will be seen on the display; however, it is not written to the History List. If jumper (JP1) is not present, check IC, -U1-35 on the MCU PWA. If it reads <1V, replace C9. If it reads >1V, replace IC, -U1
18 - 49	Not used	
50	Rate variable RAM failure (MCU internal RAM failure)	Replace IC, -U1 on the MCU PWA. If problem persists, replace the MCU PWA
51	Volume Parameter, checksum error (MCU internal RAM failure)	Replace IC, -U1 on the MCU PWA. If problem persists, replace the MCU PWA
52	Phase loss of more than one motor	Replace the pumping mechanism
53	PS valve motor cannot resynchronize	Replace the pumping mechanism
54	I/O valve motor cannot resynchronize	Replace the pumping mechanism
55	Plunger motor cannot resynchronize (flag sequence too long)	Replace the pumping mechanism
56	Plunger motor cannot resynchronize (no flag recognized)	Replace the pumping mechanism
57	PS valve motor phase loss	Replace the pumping mechanism
58	I/O valve motor phase loss	Replace the pumping mechanism
59	Plunger motor phase loss	Replace the pumping mechanism
60	I/O valve motor phase loss	I/O phase loss occurs while trying to resynchronize plunger motor. Replace the pumping mechanism

Table 5-1. Malfunction Error Codes and Corrective Action		
Error Code	**Malfunction Description**	**Corrective Action**
61	RAM failure in the motor S/W module	Replace IC, -U1 on the MCU PWA. If problem persists, replace the MCU PWA

5.5 TROUBLESHOOTING

Pump problems or symptoms and their corrective action are listed in *Table 5-2, Troubleshooting the Pump.*

Table 5-2. Troubleshooting the Pump	
Problem/Symptom	**Corrective Action**
Battery icon is displayed when pump is plugged into AC power	Check AC line fuses, F1 and F2. Replace the fuses as required
Pump will not turn on	Check battery connection. Disconnect and reconnect battery connectors. If problem persists, check fuse F3 on the Power Supply PWA. Replace the Power Supply PWA
Pump generates false EMPTY alarm	Confirm front of bubble sensor on faceplate is clean. If problem persists, replace the pumping mechanism
Pump generates false OCCLUSION alarm	Confirm there is no residue interfering with movement of the pressure detector pin. If problem persists, replace the pumping mechanism
Pump generates DOOR CASSETTE alarm during self-priming.	There are three possible indicators: faulty administration set; air in the pumping chamber; faulty valve. Replace the administration set. Restart the pump. If problem persists, check and clean the pressure pin of residue. If problem recurs, replace the pumping mechanism
No audible tone occurs during an alarm condition	Check buzzer and IC, -U5 on the MCU PWA. Replace components as necessary. If problem persists, replace the MCU PWA
Pump continues pumping when no fluid is in the line	Confirm the front of the bubble sensor is clean. If problem persists, replace the pumping mechanism
Fluid flows between the feed and flush lines	Be sure clamps are closed whenever the door is open. Replace set, if necessary. If fluid continues to flow, one of the valves is malfunctioning. Replace the pumping mechanism

Table 5-2. Troubleshooting the Pump	
Problem/Symptom	**Corrective Action**
The administration set is only partially primed distal to the cassette	Replace set, if necessary. If complete priming does not occur, one of the valves is malfunctioning. Replace the pumping mechanism
Through operation, battery life is known to be less than eight hours	Charge the battery for at least 16 hours. If problem persists, replace the battery. If problem recurs with new battery, check the charge current into the battery. (See functional description of Power Supply PWA)
Display backlight is not on when pump is not in RUN mode	Check backlight drive circuit on the Display PWA. If problem persists, replace the Display PWA
LCD segments are missing	Confirm the LCD pins are secure in their sockets. If problem persists, replace the LCD. If problem recurs, replace the Display PWA
Door does not close properly	Check door area for obstruction, and reclose. Check for correct pin(s) placement in the faceplate, as shown in Figure 3-5. Check for damaged or broken door components; replace the components or door assembly
Cannot insert cassette; plunger is obstructing cassette	Turn pump on while pressing lightly on the pressure detector pin. The plunger should retract to home position. If plunger does not retract, replace the pumping mechanism
No OCCLUSION alarm tone when an occlusion is present	A potential faulty administration set; replace set. If problem persists, check and clean the pressure detector pin of residue. If problem recurs, replace the pumping mechanism
The control knob/switch position does not match the display legend	The rotary switch decode is incorrect. Check IC, -U4-10, on the Display PWA. If problem persists, replace the Display PWA
The [ARROW] keys do not operate in SET RATE and SET DOSE positions. The [AUDIO HI/LO] key does not operate	Check for faulty key switch on the Display PWA. If problem persists, replace the Display PWA